

is vertically upward, or perpendicular to such layers. Stefan applied some of his formulas to the phenomena of ice formation in the polar seas, notably in the Gulf of Boothia, Assistance Bay, Port Bowen, Walker Bay, Camden Bay, and others, and

computed the value of  $\alpha_1$ , which is  $\frac{k_1}{\rho_1 c_1}$  to be 0.0042 (C. G. S.)

which value lies between the value of Neumann (0.0057) and that of Forbes (0.00223). This is rather a remarkable result. But Stefan's application must be criticized because he took simply for the surface condition  $\theta = \theta_1$  for  $x=0$ .  $\theta_1$  is primarily the temperature of the outer surface of ice, and not that of the atmosphere itself, as Stefan assumed. Hence our surface

condition must be  $\left[ k, \frac{\partial \theta_1}{\partial x} \right]_{x=0} = \sigma (\theta_1 - \theta_a)$  when  $\sigma$  is the emis-

sivity of ice and  $\theta_a$  may be the temperature of the atmosphere, if we assume that heat is radiated from ice surface toward the atmosphere only and not toward space. The fact is, however, that the influence of the temperature of the atmosphere on ice formation is seemingly small. The natives of Bengal, in India, make ice in fields freely exposed to the sky. Small excavations are made in the black loam soil, at the bottom of which are spread small sheaves of rice straw, and upon the top of this is placed light, loose straw to the depth of one and one-half feet. Upon this shallow and porous earthen dishes filled with water are exposed during clear nights. Ice is produced in large quantities when the air temperature is 16° to 20° F. above the freezing point. This shows that ice formation is in great part due to radiation to space. Hence  $\theta_a$  must be the so-called sky temperature, which represents both the sidereal and the atmospheric temperature.

If the temperature of the air is higher than that of ice, the ice begins to melt gradually, and at the same time a part of the heat flows into the ice downward. This is equiva-

lent to saying that cold flows outward from the interior of ice and retards the melting of the surface of ice by the warmer air. Therefore, the principles of ice formation may be applicable to this problem, if we give the formulas the opposite signs.

The penetration of frost into the moist soil is another interesting problem in the application of the theory of ice formation. If the temperature of the earth's surface is cooled below the freezing point, the frost is formed over the earth's surface and penetrates gradually deeper into the earth, which process is exactly similar to the formation of ice in a lake or in the polar seas.

All these problems are examples of heat conduction in one dimension, which is the simplest of all cases. If we suppose that a vessel filled with water is surrounded by brine, the layer of water nearest to the brine begins to freeze. Heat flows outward from the water and the layer of ice will grow toward the center of the vessel. If the vessel be a parallelepiped, our subject becomes the difficult problem of heat conduction in a parallelepiped of ice. If the vessel be a cylinder the problem becomes the most difficult, and may possibly require the assistance of the theory of Bessel's functions, if, indeed, the problem be soluble at all. It is in general very difficult to determine the variation of temperature in a limited body.

Prof. Cleveland Abbe asked me sometime ago if I could solve the problem of ice formation more completely, and if I would also prepare a paper to point out to American meteorologists how much on the subject has been done by mathematical and experimental physicists, and what ought to be done by meteorologists. Now I communicate this preliminary paper to the WEATHER REVIEW, with the hope that the problem may interest some of the theoretical as well as practical meteorologists, and also with the expectation that I may offer in the near future some more general solution of the problem than those above given.

## NOTES AND EXTRACTS.

### THE FOURTH INTERNATIONAL CONFERENCE ON AERIAL RESEARCH.

In the *Meteorologische Zeitschrift* for January Dr. A. De Quervain gives a general report on the proceedings of the fourth conference of the international committee for scientific ballooning or aerial investigation. The conference was held at St. Petersburg, August 29-September 3, 1904, in the rooms of the Imperial Academy of Sciences.

After enumerating the papers read at the conference, De Quervain gives the following abstract of Professor Hergesell's report on his kite work on the Atlantic Ocean. This work, which was carried out on the yacht belonging to the Prince of Monaco, began in the middle of July off the coast of Portugal, and was extended southward to twenty nautical miles southwest of the Canaries. From the middle of August onward the work was prolonged in the direction of the Azores after Hergesell had left the yacht. The trade wind was blowing off the coast of Portugal, and increased in strength in proportion as the yacht moved southward. North of the Canaries there was a northeast wind of seven or eight meters per second. The trade wind diminished with altitude above sea level until it was inappreciable. The kites attained altitudes as high as 4500 meters. The following conditions were observed in the trade region: in the lowest strata of a few hundred meters thick the temperature diminished adiabatically; then followed a sharp passage into a layer having an inverse gradient, generally of the considerable thickness of a thousand meters, in which the temperature rose, and which was generally very dry, namely, relative humidity of 10 or 12 per cent. Above this came another layer, with adiabatic temperature gradients, whose upper limit was not attainable, but

which certainly extended to an altitude of 5000 meters. As the kite ascended, the wind backed from northeast to northwest and diminished to a very feeble movement in the inversion layer. A southwest wind, or anti-trade proper, was not observed in these kite ascensions up to 4500 meters. Professor Hergesell considers the westerly winds observed on the peak of Teneriffe as being of a local nature. As to the presence of local winds, very interesting observations were made in the neighborhood of the Canary Islands. A general account of the results of this work will probably soon be published in the *Comptes-Rendus*, after presentation by the Prince of Monaco to the Academy of Sciences in Paris. The publication in extenso will be made in Hergesell's *Beiträgen* to the physics of the free atmosphere.

The new edition of the International Cloud Atlas has now been provided for financially and the publication will be hastened.

As to the organization of the international balloon work, the committee decided that not only should the monthly ascensions, on specified dates, continue as heretofore, but also that ascensions should be made as frequently as possible on three consecutive days during two months of 1905, namely, April and also the 29th, 30th, and 31st of August. These last dates were chosen with reference to the great total eclipse of the sun, which will occur on August 30, and on which occasion the Spanish Government desires that ascensions shall be made in Spain within the path of totality. The hour of the day for simultaneous international ascensions was postponed, since the newer meteorographs are so well protected against sunshine that they give correct records of the temperature of the air, and insolation is not so much to be feared. The committee

adopted Professor Köppen's suggestion that the ascensions take place at the hour when the ordinary observations for telegraphic interchange are made in the morning. Teisserenc de Bort, as the result of eighteen years of balloon work, states that about 4 per cent of the sounding balloons are lost, but that many times they are found, after many months, with the records in usable condition. Attention is called to the importance of special observations of clouds by experienced observers whenever balloon ascensions are made.

The committee unanimously expressed the opinion that the continuation of the publication in full of the international observations in the free air is of the greatest importance and is absolutely necessary in the progress of scientific meteorology, and requested all nations to heartily support this work, which has hitherto been supported by the German Government only, but whose cost should be defrayed by all conjointly. The Russian Government has undertaken to communicate through diplomatic channels the plan of cooperation that was devised, and will also request active cooperation in balloon work.

With regard to kite work on the oceans, the committee resolved that this had a very special interest for meteorology, and requested that individual governments should consider the propriety of furnishing apparatus and instructed experts so that regular kite ascensions might be carried out on the steamers of all lines that are subsidized by the respective governments. It is requested that meteorological institutes and scientific societies should bring this idea to the attention of all steamship companies and enlist their cooperation in this new field of work.

A modification of the kite was exhibited to the committee; namely the Kufnetzof semicylindrical kite; these kites are remarkably small and light and therefore exert a slight pull on the kite line, seldom exceeding five kilograms; consequently the weight of the cable and the strength of the reel may be correspondingly diminished. This kite was first used in Pavlosk, where it has made many high ascensions. The kite meteorograph devised by Kufnetzof is not attached to the kite, but hangs from the kite line, below it, and by means of a wedge-shaped jacket the anemometer of the self-register is made to stand vertical and quiet.

Teisserenc de Bort, while continuing to use his paper balloons, has also turned his attention to the elastic india-rubber balloons, for which he has made a new, very light meteorograph, using a bimetallic thermometer very well ventilated. Doctor Shaw, of England, exhibited a peculiar, cheap kite meteorograph devised by Dines. Professor Hergesell exhibited three different meteorographs: 1st, a light instrument for kites; 2d, the ordinary model for rubber balloons; 3d, a new instrument for manned balloons, having an electrically ventilated aspiration thermometer. The newest forms of Hergesell-Bosch self-registers have clocks made in Switzerland of nickel steel which continue to go even in the lowest temperatures.

Of the greatest importance for the accurate measurement of pressures is the principle theoretically announced by Rosenthal in his memoir on the elastic reaction of aneroids during balloon ascensions and confirmed by the experimental work done at Strasburg by Professor Hergesell, i. e., that the compensation depends entirely upon the external pressure, so that the method hitherto used to compensate aneroids against the influence of temperature under high pressures that prevail at the earth's surface introduces an error of compensation that may be equivalent to 2000 meters at the greatest heights attained by balloons. It will be very important to properly consider these investigations in studying the international simultaneous ascensions.

It is not recommended that any one form of self-register shall be adopted in general but that each be fully described and investigated when it is used. Most of the instruments now in use have some value, but all are open to further im-

provements. The Hergesell tube thermometer is undoubtedly the most sensitive, but is delicate and needs careful handling. The various bimetallic thermometers are sufficiently sensitive to allow of comparison with the tube thermometer, since the accidental error is of almost the same magnitude as the difference in sensitiveness. The important points are the calibrating and handling of the instruments, the proper consideration of the aneroid compensation, and the critically accurate reduction of the curves of the self-register.

The next conference on aerial work will be held in Rome, probably in 1906, and only members of the committee will be invited. At the recent meeting numerous outsiders were present and took part in the discussions, but the official delegates represented Germany, England, France, Italy, Russia, Sweden, and Spain. Austria-Hungary and Switzerland were represented by unofficial delegates.—C. A.

#### THE METEOROLOGIA GENERALE DI LUIGI DE MARCHI.

The author of this book is the well known professor of physical geography and meteorology at the University of Padua, the scene of Galileo's lectures which laid the foundation for modern experimental science. Besides a number of scientific memoirs, Marchi has written several popular works on climatology and meteorology. His personal studies have been in the direction of the elucidation of the dynamics of the atmosphere and the work we have in hand is the second, much enlarged, edition of a former treatise elucidating this subject; it is simply a short treatise on physical meteorology, which, as he says, has undergone a radical transformation in the past twenty years. The composition of the air, the laws for the transformation of aqueous vapor, the static and dynamic condition of a vertical column of the atmosphere are now looked upon from a different standpoint; the theories of meteorological apparatus have now become more precise; the meteorological importance of atmospheric electricity has become better defined and meteorology in general has come to occupy a higher position as a natural philosophy. A booklet of 225 pages, 16-mo, can, of course, give only a brief account of the more prominent features of our present knowledge of meteorology, but the author has apparently selected wisely and the Italian reader will certainly find this manual, which belongs to the series published by Ulrico Hoepli of Milan, leading him in the right direction and preparing him for the more critical study of advanced treatises and special memoirs.

The volume is divided into four sections and subdivided into seventeen chapters. The first section, on the atmosphere, considers the physical properties of the air and the structure of the atmosphere, the action of aqueous vapor and of atmospheric electricity. The second section relates to equilibrium and motion, barometric pressure, the laws of motion both horizontal and vertical, and the conditions of equilibrium. The third section deals with the temperature of the air, its horizontal and vertical distribution and its periodic variations. The fourth and last chapter gives the application of the preceding sections to the irregularities and the prediction of the weather; its four sections relate to simple types of isobars and their movements over the globe, followed by complex types of isobars and the practicability of the weather prediction. In a short appendix, pp. 218-23, Marchi gives the elements of the theory of the diurnal variations of the barometer together with the results of Hann's investigations, according to which the second term in the harmonic series is uniform over the whole world and may therefore depend upon something entirely outside the atmosphere, while the first term varies with latitude, temperature, and continentality.

If this popular manual indicates fairly the instruction in meteorology given in the Italian schools, then it must be acknowledged that they are in advance of the high schools of the United States. We see no reason why a popular manual